ECONOMIC IMPACT OF MIXED CROPS IN SUSTAINABLE AGRICULTURE IN THE CONTEXT OF GLOBALISATION: A CASE STUDY IN DAKSHINA KANNADA DISTRICT.

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INTRODUCTION

Agriculture continues to be the mainstay of the Indian economy as it is a major source of livelihood for more than two-thirds of population. There is a strong correlation between agrarian prosperity & demand for manufactured goods and modern services across the country. This visible correlation tells us that the route to sustaining high economy-wide growth rates has to be through accelerated agricultural development. (Dr. Manmohan Singh, Prime Minister of India, Oct 2006). Agriculture provides the bulk of wage goods required by the non agricultural sector as well as the raw materials for the industrial sector. Today, India ranks second worldwide in farm output. Agriculture and allied sectors accounted for 14.2% of the GDP in 2011, employed 59% of the total workforce and despite a steady decline of its share in the GDP, is still the largest economic sector and plays a significant role in the overall socio-economic development of India. India is the largest producer in the world of milk, cashew nuts, coconuts, tea, ginger, turmeric and black pepper, and has the world's largest cattle population (281 million). It is the second largest producer of wheat, rice, sugar, groundnut and inland fish. It is the third largest producer of tobacco. India accounts for 10% of the world fruit production with first rank in the production of banana and sapota. The word 'Agriculture' means production of crops of various types. A crop can be defined as a season's or annual yield of any plant that grows in significant quantities to be harvested as fuel, food, livestock fodder or for any other economic purpose. In the words of Johnston and Mellor "Certain aspects of agriculture's role appear to have a high degree of generality because of special features that characterise the agricultural sector during the course of economic development". Many growth theories, using different approaches, have revealed that agricultural development is instrumental to overall economic growth. The ability of agriculture to contribute directly to economic growth is, however, dependent on the level of incomes and the resultant surpluses in the agricultural sectors. The level of farm incomes besides being the principal detriment of welfare of farm families thus emerges as one of the important factors that condition economic growth. Palniappan (1984) stated that any farming system, if the

management, resource allocation and decision making are restricted to only crop husbandry, it is known as cropping system. If the farming system were extended to other farm enterprises like dairying, it is known as farming system. The agriculture and agriculture-allied activities comprise horticulture, sericulture plantation, dairy and dairy products, and livestock, fishing and rearing of pigs. Both agriculture and its allied activities are in combination and not separable in rural life. Hence in general, the term 'Agriculture' connects all the above activities.

Over the last three decades, the Indian agriculture has shifted towards a specialized cropping pattern that is primarily oriented towards the production of food grains. However the external sector reforms in India, particularly after the post Uruguay Round, are expected to usher in an influx of cheap food imports which have wide implications for such production regimes, Moreover, wheat-paddy water intensive cropping cycle that is widely prevalent in the western part of Indo-Gangetic plains tend to exhaust natural resources in a manner that may be sustainable. Moreover, the South Asian region has also witnessed stagnating technological advancement and declining investment in agriculture, in general, and in irrigation, in particular (Joshi.et al, 2002) under such circumstances mixed cropping system is one of the more rational responses that can counter emerging challenges associated with crop- specialization.

RESEARCH PROBLEM

Mixed cropping system has biological advantages over the mono cropping system. However, in real life, it usually is not biological but economic advantage which decides what farming and cropping systems are actually used. The past experience indicates that agricultural research in India has focused mainly on increasing the productivity of crops, while the farmers' objective is to realize better profitability. Hence it is evident, that for better adoption of research results by the farmers, more attention is required on the economic aspects of the evolved technologies in addition to productivity. Economic analysis carried out with farming system perspective considers all the major components of the farm and their technical and functional relationships; hence the results of these studies are more relevant under the real world situations. **However, these studies were based on annual crop based farming systems, in which the return to investment was realized within a year. Mixed crops consist of perennial crops and its distinct features are:**

- Long economic life span.
- Multiphase of growth and bearing
- Continuous flow of cost and return over a number of years with varying magnitude
- Long gestation period between the investments in the initial years and pay-off in later years and
- Influence of present input on future output necessitates a different approach for performing the economic analysis.

Hence, while performing the economic analysis in perennial crops, in addition to the maintenance cost, the return from a plantation should therefore cover the initial investment along with its interest. For this, Das (1984) has suggested that the annuity value of the initial investment should be added based on the economic life span of the crop to its annual maintenance cost to work out the cost of production. This approach was subsequently followed by Babu et al. (1993) for performing the economic analysis of other smallholder plantation crops. However, farmers cultivating small holder plantation crops like coconut and arecanut, seldom maintain records of input and output and hence compilation of data for economic analysis of these crops is a tedious task. **The economic analysis of perennial crops performed in the earlier studies were restricted to estimation of cost of cultivation, gross and net returns of a single component of the farm. They were mostly based on either experimental data from research stations. In contrast, in the present study, an attempt is made to perform the analysis of mixed cropping system along with coconut as main crops under farmer's field conditions.**

RESEARCH ISSUES: EARLIER STUDIES.

The chapter 2 highlights important findings of the studies, summary of the findings and has drawn the issues for research. Several studies have been carried-out to examine the impact of mixed cropping system on economic development at the global, national and regional level.

Dhingra et al (1991), reported that crop production can generally be increased by three means viz. increasing the area under cultivation, increasing the potential yield of crop by breeding and intercropping or mixed cropping. In the recent past evidence point out that mixed cropping exhibits more yield than sole cropping.

Mollison (1901) stated that the system of mixed crops, so common in India. is undoubtedly a successful and profitable method which probably has done more to uphold the fertility of the Indian soils than any other practices.

Aiyer (1963) reported that in mixed cropping all the resources with regard to plant nutrients present in the soil or added to it as manures are utlised by component crops more efficiently than when a crop is grown in mono culture. Mixed cropping may also lead to increase in production per unit area, per unit time without affecting the production of the main crop to a great extent. Among the intercrops, leguminous crops help to increase the soil fertility by fixing atmospheric nitrogen. Utilization of nutrients, moisture space and solar energy can be derived through mixed cropping of cultivation.

Sarkar and Shet (1990) reported that mixed cropping not only stabilize crop production by reducing the impact of weather vagaries but also increases the cropping intensity considerably.

Willey and Osiru (1972) reported that mixed cropping system involves growing two or more crops of Consideration habit with the assumption that they could exploit the total environment more efficiently than a monoculture and result in increased overall production yield per unit when properly planned and managed this has added advantages such as enhanced net returns, favourable economic social and environmental benefits and increased employment.

Andrews (1970) gave general criteria to obtain increased returns from mixed cropping.

- Inter crop competition must be less than intra crop competition.
- The arrangement and relative number of contributing crop plants will affect the expression of the differences in competition.
- The effect of competition between crops is greatly alleviated when their demands on the environment occur at different times.
- The legumes may be necessary component crops under conditions of poor fertility.

Willey (1979) reported that yield advantage in mixed cropping system occurs because component crops differ in their use of growth resources. In terms of competitions, this means that in some way the component crops are not competing for exactly the same overall resources and thus mixed crop competition is less than intra crop competition. Maximising the mixed cropping advantages is therefore, a matter of maximizing the degree complementary between the component crops and minimising intercrop competition. The main way those complementarities

can occur, is when the growth patterns of the component crop differ in time. Advantages occurred where the only difference between component crops is of time rather than crop type.

Swaminathan (1980) stated that mixed cropping system should be based on complementarity between the companion crops and the components of complementarity are :

- Efficient interception of sunlight
- Ability to tap the nutrients and moisture from different depths of soils.
- Non overlapping suplebility to pest and diseases.
- Introduction of legumes of promote biological nitrogen, fixation and increase protein availability.

Mollison in his text book of Indian Agriculture (1901) also wrote that the system of mixed crops so common in India is undoubtedly a successful and profitable method which probably has done more to uphold the fertility of the Indian soils than any other practices. Among the different practices of crop growing, intercropping is common one when a main crop is of long duration.

Ayyangar and Ayyer, (1942) reported that Intercropping is mainly practiced to cover the risk failure of one of the component crops due to vagaries of weather or pest and disease incidences. When annuals or seasonal crops are grown under coconut, it is called intercropping. When different crops combinations are introduced into coconut holdings, the system is generally designated as mixed cropping. Due to unsustainable profitability from coconut monoculture and fluctuating coconut prices, priority has now been assigned for efficient utilization of the biophysical resources under coconut for increasing income and employment from a unit area. Numerous studies have been reported that mixed cropping along with coconut as main crop is more profitable than coconut monocrop and, as a result, several mixed cropping practices along with coconut have been evolved for improving soil fertility status, nutrient cycling and nutrient addition and optimum utilization of water and solar radiation available under coconut.

Friend, (1999) reported that the main characteristics determine the suitability of coconut gardens for mixed cropping system is space between the coconut trees. The spacing for planting coconuts ranges from 7 m x 7 m to 10 m^x 10 m for tall cultivars, with an average planting density of around 150-180 palms per ha, and as close as 5.5 m * 5.5 m for dwarf palms giving planting densities as high as 400 palms per ha depending on the adoption of whether rectangular, square or triangular system of planting.

Kushwah et al., (1973) reported that in coconut mono cropping as little as 25 percent of the land is effectively used.

Reynolds, (1995) reported that, clearly coconut mono cropping has a very low utilization efficiency of agricultural land and even with varietal improvement it is likely to remain so **Bavappa, (1975)** stated that, The morphological features of the coconut occupy less than 30-40 per cent of the available air space between canopy and ground during the major part of their life span.

Nelliat et al., (1974), reported that on an average about 56 per cent of solar radiation is available for intercrops planted under coconuts, although this will vary with age of the coconut stand and planting density. The spread of the roots is mainly in the 30-120 cm soil layer, in a 2 m radius around the palm thus leaving about 70 per cent of the soil unutilized or underutilized. Over 80 percent of active roots of nine year old palms were found to be confined to an area of 2 m radius around the palm and to the 25 to 60 cm soil depth. In Brazil, the largest quantity of roots of six-year-old dwarf coconut cultivars was found in the 0.2-0.6 m horizon and 90% of total roots and 85% of fine roots within a radius of 1.5 m around the stem.

Etherington and Kantnanavakc, (1981)reported that introduction of dwarf varieties and the closer spacing of hybrids and tall cultivars may reduce possibilities for mixed cropping, but at present most of the coconut palms in the world belong to the tall varieties planted at wider spacing. In future plantings the choice of spacing may be influenced by the decision to diversify the coconut lands through intercropping.

Whitchead and Smith. (1968) reported that the very nature of the coconut palm is that there is a large area of land under the palm canopy which the farmer has to decide how to utilize. Weeds will grow beneath the palms if unutilized and has to be kept at bay by a variety of means or by establishing mixed crops. However, weeds could be replaced by forage species whose growth could be controlled by grazing animals.

Payne, (1976) divided the life span of coconut crop into three distinct phases, based on the growth habit of the coconut palm and the amount of light transmitted through its canopy from the point of view of mixed cropping. They are -:

- Planting to pre-bearing (below 5 years): Good light transmission initially, but decreasing with age, suitable for growing annuals / biennial intercrops.

- Young trees (5 to 20 years) Maximum ground coverage and low canopy poor light availability – not suitable for profitable intercropping.
- Matures trees (over 20 years) increase in trunk height ; reduction in crown size; light transmission increasing with age, ideal for raising annual and / or perennial crops.

Nair and Rao (1977) observed that the rate and extent to which biophysical resources are captured and utilized by the mixed cropping system along with coconut is determined by the nature and intensity of interaction between the components. The net effect of these interactions is often determined by the influence of the coconut palms on the other component(s) and/or on the overall system, and is expressed in terms of such quantifiable responses as soil fertility changes, micro climate modification, resource (water nutrients, and light) availability and utilization, pest and disease incidence, and allelopathy.

Van Noordwiik et. Al. (1996) reported that efficient use of soil resources for improvement in the productivity of coconut holdings is one of the main reasons for integrating palm with other synergistic crops and livestock. In mixed cropping systems with trees, the knowledge of the vertical root distribution is crucial for the optimization of resource use. The ability of palms to access subsoil nutrients and water depends on several factors such as the variety, soil physical and chemical properties, palm management and the cropping system.

Sankaranarayana and Velayutham, (1976) reported that soil type and conditions play an important role in the selection of subsidiary crops for the mixed cropping systems. Coconut is grown under diverse soil conditions ranging from littoral sands to clayey soils, ill drained low lying areas to well drained hill slopes, strongly acidic peaty soils to alkaline cal carious soils. Description of different soils under coconut in the world is available in many publications.

Steel and Humphreys (1974) reported that major soils on which extensive cultivation of coconut is undertaken are laterite, lateritic red sandy loam, sandy, alluviums, coal, peaty and black soils. Most of these soils, except ill-drained low-laying areas and alkaline soils are suitable for raising a number of inter and mixed crops. In coconut gardens 70-75 percent of the land remains unutilized or underutilized.

Anilkumar and Wahid (1988) reported that palm roots were very dense in an area of 3m from the trunk and they observed that over 80 percent of active roots were confirmed to an area of 2 m radius around the palm and 25 to 60 cm soil layer.

Kushwah et. Al. (1973) observed that roots of adult bearing coconut palm growing in sandy loam soil under 7.5 x 7.5m spacing and normal management are concentrated within a radius of 2 m around the palm, thus utilizing only about 22% of the soil on area basis. Vertically, the top 30 cm layer of the soil is practically devoid of functional roots and about 85% of the roots are found between 30 and 120 cm depth from the surface. In a pure stand of coconut, more than 75% of the soil mass is available for foraging by other crops thus facilitating growing of various crops along with coconut palms.

Magat (2007) observed that about 80% of coconut lands in the world are cultivated by small scale farmers (with only 2 ha or less). Unfortunately, these smallholdings are mainly committed to a monocrop of coconut, which normally occupies the land for about a century. Under such monocrop system, majority of the coconut holdings do not generate adequate income and employment for the dependent families. From the land utilization point of view, a pure stand of coconut utilizes only 22% of the area at a spacing of 7.5 x 7.5 m leaving nearly 78% of the area underutilized. A hidden wealth needs to be tapped under the tree of life, A well spaced coconut garden provides adequate inter and intra-row spaces where it is possible to grow a variety of useful seasonal and perennial crops.

Ohler, (1999) observed that Gabi, ramie and chilli pepper gave higher yields under coconut than in the open.

Carcallas and Aparra, (1983) stated that, there is a need to select shade-tolerant crops for intercropping. There was significant increase in nut yield when palms were intercropped, ring weeded and fertilized. Increased nut yields are believed to be attributed mainly to fertilization and inter-row cultivation. However, leguminous annuals could contribute to increased nut yields through nitrogen fixation in the roots. Intercropping with annuals does not only increase profitability, but is beneficial to the palms as well. The proportional increase in yields in terms of copra per nut and copra per tree are attributed to appropriate intercropping.

Liyanage and Dassanayake (1993) stated that in Sri Lanka, grain legumes are popular intercrops under coconuts in the low country semi-dry intermediate zone, While winged bean (Psophocarpus palustris) yielded 1117 kg / ha of grains, the average levels of productivity for pigeon pea and cowpea were 1000 and 815kg / ha respectively.

THE ECONOMIC IMPACT OF MIXED CROPPING SYSTEM

In coconut holdings the land under coconut is amenable to profitable utilisation during the pre-bearing and post-bearing phases. By growing agricultural crops as well as tree species in compatible combinations with or without the presence of farm animals and related enterprises under coconut, the net income per unit holding could be augmented many times than that from a mono cropping. Such integrated use of coconut holdings also renders many other benefits such as enhanced employment opportunities, availability of multiple farm produce and ecological sustainability.

In a 4 ha crop model studied in Sri Lanka, pineapple, banana, ginger, papaya and lime were planted along with coconut in 1987. Although there was no profit in the first two years, the situation was different in the third year with considerable profit. In the 4 ha crop model studied in Sri Lanka, the profit at the end of the third year was Rs. 123,715. This proves that when diverse crop models appropriate to local agro climatic conditions are promoted, considerable income could be generated from holdings devoted to coconut even during the pre-bearing phase. The profitability of growing perennial/semi perennial crops as well as seasonal crops under coconut has been conclusively established in different studies conducted in Sri Lanka.

Mixed cropping system along with coconut as main crop, have been found to create additional employment opportunities for the local farmers in Sri Lanka. In one study the employment potential was found to increase by 300 per cent in coconut mixed cropping systems. According to the results of a survey conducted by the Agrarian Research and Training Institute in the Colombo district of Sri Lanka, a 20 ha unit of class II coconut land when mix cropped could provide fuller employment for 20 labourers at a monthly income of Rs. 354 (Liyanage, 1974).

In the Philippines performance of different combinations of black pepper, pineapple, papaya and cacao under coconut was studied and economic analysis of the system was made. Among the different combinations the system containing coconut + black pepper + pineapple + cacao produced the highest net return followed closely by the combination coconut + black pepper + cacao. The lowest margin exhibited by the combination coconut + black pepper + papaya was mainly because of higher variable cost at the initial production stage of the intercrops. The results of this study clearly revealed the scope for increasing the profitability of coconut farming by introducing appropriate cropping pattern under coconut.

Mixed cropping when continued with greater cropping intensity also exhibited a significant positive influence on the volume of whole nut, copra out-turn nut and weight of shell. In 1985 significantly more nuts (64 to 90% increases) and higher copra output tree (70 to 105% increases) were obtained from intercropped farms than from mono cropped units (Gapsin, 1986). In addition to causing improvement in the productivity of land under coconut, crop mixing was also instrumental in increasing on-farm employment opportunities. In 1983, a cropping pattern of coconut + pineapple + papaya required 168 man days yr^{1} while coconut + coffee + banana + pineapple +papaya required 202 mandays yr''^{1} as against the usual requirement of 150 mandays $yr'ha'^{1}$ in the Philippines.

Mixed cropping in coconut gardens refers to growing annual / seasonal crops under coconut for profit and sustainability. Mixed cropping systems are site-specific and must be designed to meet local soil fertility conditions, rainfall characteristics, farmers' resources and management skills, working habits, land tenure systems, market situation and economic infrastructure. Profitable intercropping with annual/seasonal crops is possible up to 5^{th} year of planting coconut or after about 20 years after planting, as the growing coconut canopy does not allow proper growing of intercrops during this intervening period due to inadequate availability of light underneath. In newly established coconut plantations, mixed cropping annuals may provide quick cash returns, thus generating income when the palms have not yet reached bearing. In flat land and gentle slopes certain species of annuals can provide good ground cover, minimizing erosion and improving moisture retention. Variety of annual crop groups such as cereals, grain legumes, root and tuber crops, oil seed crops, annual spices like ginger, turmeric and coriander have been found suitable to grow below the coconut under various agro-ecological situations.

The economics as well as social benefits of mixed cropping system along with coconut as main crop were evaluated under different conditions and the findings justified the promotion of such systems on a wider scale for the benefit of the farmers. Studies carried out by the Kerala Agricultural University (KAU) at different centers during 1967-1974 clearly showed that intercropping was of great economic advantage to the small and marginal farmers. The practice when organised systematically has resulted in an overall increase in income and on-farm employment.

SIGNIFICANCE OF MIXED CROPPING SYSTEM

Mixed cropping means growing several crops simultaneously has been devised as a means to overcome the drawbacks of mono cropping. The underlying assumption of such mixed cropping is that at least some of the crops would survive, even if others fail due to the unforeseen contingencies or calamities. A mixed crop leads to higher income and they impart stability in incomes. They also ensure better utilization of land and helps in maintaining soil fertility. They also serve to provide a certain amount of insurance against risks and uncertainty of weather and a certain amount of protection against damage to crops caused by pests and diseases. Under mixed cropping, certain nutrients exhausted by one crops are replenished by another, as a consequence, a certain amount of balance is maintained. Mixed cropping can increase organic cereal and grain legume protein production and will safeguard the farmers' earnings while contributing to increased agro-biodiversity in farming systems. The main aims of mixed crop were identifying benefits and obstacles for the far more extensive and flexible use of mixed cropping of arable crops in order to resolve both the technical and socio-economic aspects. It increases the knowledge on the multifunctional role of intercropping like production level and stability, resource use, environmental impacts, and product quality of intercrops. It develops a simulation model for modeling grain legume-cereal intercrops, which can be used in the design of intercrops and strategic planning of cropping systems with intercrops, design and test new methods for mixed cropping.

SIGNIFICANCE OF THE PRESENT STUDY:

The focus of this study is to evaluate and compare economics of major mixed cropping systems along with coconut adopted by the farmers in the study area. The economic performance of the crop is assessed based on the cost of production and net return obtained per unit area. The empirical data on the physical inputs and net return per unit area would be extremely useful to the farmers, as well as for policy makers to augment the productivity and production of mixed cropping systems. Such studies are also useful to commercial banks and other credit institutions for in estimating the financial requirements for cultivation and formulating their lending policies. Even such studies are also helpful to coconut traders in fixing price and to provide incentives to

the farmers. In the study region, expansion of mixed cropping along with coconut area is increasing faster due to farmer's attitude towards commercial cropping system mainly because of labour problems in paddy cultivation and fragmentation of land. So far no such research study on economics of mixed cropping system along with coconut has been conducted in this area. Since coconut is the major commercial crop of this region, hence an attempt is made through this study to estimate the costs and returns, resource use efficiency and problems faced by the farmers of mixed cropping system along with coconut. It may serve as a basis for advocating appropriate changes in the prescribed cropping pattern and to suggest rational cropping patterns.

OBJECTIVES OF THE PRESENT STUDY:

The present study aims at identifying and evaluating the mixed cropping systems along with coconut as main crop followed in Dakshina Kannada district of Karnataka. In the light of these aspects the present study was purposively undertaken in Dakshina Kannada district .The overall objective of the study was to identify and compare the major mixed cropping systems along with coconut as main crop practiced by the farmers and to determine the system, which fetches the maximum income to the farmers in Dakshina Kannada district. Therefore the present investigation was undertaken with the following specific objectives.

Specific objectives of the study

- To study the socio-economic conditions of farmers of mixed cropping system along with coconut as main crop.
- To analyze the cost and returns structures of major crops in mixed cropping system.
- Income and employment generation in mixed cropping system along with coconut as main crop.
- To analyze resource use efficiency in mixed cropping system along with coconut as main crop.
- To identify the problems faced by the farmers in the mixed cropping system along with coconut as main crop.

THE HYPOTHESES:

- Mixed cropping system is an alternative pathway of seasonal unemployment.

- Mixed cropping system is more remunerative than mono cropping system.
- The resources are more efficiently utilized in mixed cropping system along with coconut than under mono cropping system.

METHODOLOGY

To examine the above mentioned objectives farmers cultivating mixed crops were chosen from the study area. Farmers particularly marginal, small, medium and large were selected for the above purpose. Multistage sampling technique was adopted for the study. In the first stage, Dakshina Kannada district was selected for the study because of all the five taluks growing mixed cropping systems along with coconut as main crop. In the second stage, all the five taluks of the Dakshina Knnada district were selected as they had the largest area of mixed cropping systems along with coconut as main crop. Third stage comprised selection of villages. There are 80 and 100 villages in Belthangady and Mangalore taluks and 81, 67, and 40 in Bantwala, Puttur, and Sullya taluks respectively. The village wise area under coconut, arecanut, banana, pepper and pineapple in different villages during 2007-08 was obtained from the Assistant Directorate of Horticulture and revenue department of respective taluks. Then the villages were arranged in descending order with respect to coconut for cropping system I (coconut as monocrop), cropping system II (coconut with arecanut), cropping system III (coconut with areacanut with banana), cropping system IV (coconut with areacanut with banana and Pepper), cropping system V (coconut with areacanut with banana with Pepper and Pineapple). Villages having the highest area under those 5 crops were considered and two top villages were selected from each taluks.

The fourth stage is concerned with the selection of the sample respondents from the villages. Thirty farmers were randomly selected from each village under different cropping system. Total sample farmers selected were 300 from ten villages and 60 each from five taluks of Dakshina Kannada district for all the cropping system.

In order to undertake the proposed study both primary and secondary data related to mixed crops were collected from different farmer categories through field study. The data was collected by personnel interview method using a pre-tested questionnaire for the agriculture year 2007-08. The data so collected relates to

a) General characteristics such as name, educational qualification, occupation, land holding and its type, area under coconut gardens, area under mixed cropping, year of planting, year of first harvesting etc.

b) Investment details for the establishment of coconut garden, coconut with arecanut garden, coconut with arecanut with banana with Pepper and Pineapple gardens, investment related to pump set, pump house, implements and cost structure, details on returns of the mixed crops.

During the survey it was observed that majority of the farmers were not maintaining proper records about expenditure and income of the crops. Hence data were based on memories of respondents. However all the efforts were made to convince the farmers about the purpose of the study to elicit the accurate data. The help of local leaders, horticulture officers and statistical assistants was sought to minimize the magnitude of bias entering into the research.

Statistical analysis was done by using simple statistical tools. Mean and standard deviation was estimated by using quantitative data. Spearman's rank correlation was estimated to find the correlation between total cost with net returns and gross returns and also to find out material cost and labour cost. All these above mentioned tests were done by using statistical packages SPSS VERS 11.5. $P< 0.05$ was considered to be statistically significant.

LIMITATIONS OF THE STUDY

Since data were collected by survey method, the inherent lacunae associated with this type of enquiry might have crept into the study, since estimates were taken by recollecting from memory of respondents. Sincere efforts have been made to elicit the accurate information by cross questioning. However, the degree of discrepancy, if any, would be negligible.

PRESENTATION OF THE STUDY

Chapter – 1:- Introduction

This chapter is introductory in nature and it deals with agriculture and economic development- Globalisation and its impact on Indian agriculture- principal mixed crops: nature of crops, cultivation methods and production and productivity- The economic impact of mixed cropping system- Significance of mixed cropping system - Significance

of the present study - Research problem-Objectives of the present study - The hypotheses outlined for the study –Methodology - Limitations of the study - Presentation of the study

Chapter – 2:- Review of literature

In this chapter, a review of past research work in the field has been compiled to enable better understanding of the research in various regions and methods of analysis. The review of literature throwing light on the following issues is explained in this chapter.
Economic impact of mixed crops - Coconut cultivation and mixed cropping system - Income and employment generation in mixed cropping systems - Resource use efficiency under mixed cropping systems - Constraints in mixed cropping systems.

Chapter – 3:- Description of plantation crops

The third chapter provides description of plantation crops – Introduction – Plantation crops and its global scenario - Plantation crop in India - Plantation crop in Karnataka - Plantation crop in Dakshina Kannada District.

Chapter-4:- Profiles of study area

The fourth chapter gives profiles of study area and it is an attempt to examine some important aspects of the selected cropping systems, such as income and employment generation, input use efficiencies and problems faced by the farmer respondents in the study area. - Description of the study area - . Sampling procedure - Nature and source of data- Analytical techniques employed - Definition of terms and concepts used.

Chapter -5:- Emergence of Mixed Crops and Sustainable Agriculture

The fifth chapter presents the details of Emergence of Mixed Crops and Sustainable Agriculture and a healthy agro-ecosystem can be achieved by mixed cropping system based on biodiversity, greater use of local resources and biological inputs and "judicious use of agro-chemicals' - Introduction - Problems under mono-cropping system - Emergence of mixed cropping system and its advantages - Mixed cropping system along with coconut convert mixed cropping holdings into viable agro ecosystems - The importance of coconut cultivation along with other perennial crops in the national economy - Conclusion

Chapter –6:- Analysis, results and findings

The sixth chapter provides the results of the analysis of the data collected for assessing the set objectives of the study they are - Socio- economic Characteristics of Sample

farmers cropping pattern followed in the study area.- Economics of mixed cropping system along with coconut as main crop in the study area. Cost and returns structure of different cropping systems - Income and employment generation under different mixed cropping - system along with coconut as main crops - Resource use efficiency under different mixed cropping system along with coconut as main crop.- Constraints associated with different mixed cropping system along with coconut as main crop.

Chapter -7:- Summary, Policy implications and Conclusions.

The last and final chapter presents summary, Policy implications and conclusions of this research. Coconut is one of the important commercial plantation crops of South India, having wide range of uses both as edible oil and industrial products. Arecanut, banana, Pepper and Pineapple are also important perennial crops which are taken as mixed crops in coconut gardens. Dakshina Kannada district is one of the major producers of these crops. The overall objective of the study was to examine the economic feasibility of investment in mixed cropping systems along with coconut as main crop.

IMPORTANT FINDINGS OF THE STUDY

1. DEMOGRAPHIC FEATURES AND GENERAL CHARACTERISTICS OF THE SAMPLE GROWERS.

The average size of the family of coconut mono cropping system coconut growers consisted of 57 per cent adults and 43 per cent children. The family of coconut with arecanut growers comprised of 50 per cent each of adults and children. The family of coconut with arecanut with banana growers 55 and 45 per cent adult and children were observed. The family of coconut with arecanut with banana with Pepper growers 55 and 45 per cent adult and children were observed. And in family of coconut with arecanut with banana with Pepper and with Pineapple growers 55 and 45 per cent adult and children were observed. There were 25 per cent, 20 per cent, 38 per cent, 32 % and 35% joint families in coconut, coconut with arecanut, Coconut with arecanut with banana, coconut with arecanut with banana with pepper and coconut with arecanut with banana with Pepper and with Pineapple respectively.

In all the five categories of cropping systems, the family type of sample farmers was nuclear indicating increased subdivision and fragmentation of land holdings in the plantation area. Thereby it supports the statement that most of the coconut growers are small and marginal farmers in India and Smallholder agriculture in the tropics is characterised by Mixed cropping.

In future we have to go 'vertical' rather than 'horizontal' in agriculture development i.e. to increase productivity per unit area/time. This is only possible through the cultivation of mixed cropping system with high yielding varieties of crop plants.

It was interesting to note that about 38-50, 30-42 and 20-25 per cent of the farmers completed high school, college and primary education, respectively. None of the sample farmers were found to be illiterates in the study area. This reflected that, it is easy for transformation of technology in the study area to increase the production and productivity of mixed cropping system along with coconut as main crop.

The average size of the holding was 3.5, 2.5, 3.5, 3.5 and 3.05 hectares in cropping system I, II, III, IV and V respectively. Coconut growers planted both west coast tall and local variety. However, majority of the farmers (80%) adopted local variety as most of the gardens are found to be old. It was found that in all the systems (cropping systems I to V), cultivation of local varieties of coconut and arecanut was common practice in the study area. In India, most of the coconut growers are small and marginal farmers. The income derived from most of the coconut holdings is insufficient to sustain the dependent families. One of the feasible ways of increasing the farm level income on such small coconut holdings is to resort to growing compatible annuals or perennials. Thus growing of suitable intercrops will help them to get additional returns. Smallholder agriculture in the tropics is characterised by mixed cropping, with several crops intercropped together, within which competition for resources is determined by the temporal dynamics of their availability in relation to the growth patterns of the different species.

2. CROPPING SYSTEM FOLLOWED BY SAMPLE FARMERS.

The farmers of all the five systems were growing field crops also. This clearly reflected that most of the farmers who are practicing mono crop of coconut and mixed crop along with coconut as main crop got the returns from other cropping systems also. This was due to the fact that rice was the staple food of study area and hence the cropping pattern of paddy-paddy and paddy-Pulses accounted for almost 50 per cent of cropped area. This proved the statement that Dakshina Kannada was portrayed by the colonial masters as a rocky, mountainous country transacted by numerous small rivers bounding in lofty forests. It was described as a poor soil which produced “nothing but rice and coconuts. However the farmers who are practicing mixed cropping system along with coconut as main crop was only taken into account.

3. ESTABLISHMENT COST OF FIVE CROPPING SYSTEMS.

During the first 7 years of gestation period huge capital was required to establish the gardens. Though the major investment was in the first year, in the remaining years, the farmer had to incur the expenditure on input and other operations to maintain the garden. No mixed crops were taken in mono crop of coconut. The investment on cropping system V required highest amount of Rs.6,31,134.74 followed by cropping system IV (Rs.5,54,263.46), cropping system III (Rs.4,60,231), cropping system II (Rs.4,01,197), and coconut mono crop system (Rs.3,02,827). Out of the total establishment cost, the material cost constituted 62.9 per cent for cropping system I, 40 per cent for cropping system II, 45.53 per cent for cropping system III, 43.14 per cent for cropping system IV, and 40.2 per cent for cropping system V. The next major share of total establishment cost was labour Cost which was 37.1 per cent for cropping system I, 65 per cent for cropping system II, 54.47 per cent for cropping system III, 56.86 per cent for cropping system IV, and 59.8 per cent for cropping system V.

The results thus clearly indicated that the material cost was the major component of the establishment cost for all the five gardens. Since labour charge occupied a reasonable share in the total establishment cost, it could be inferred that mixed cropping system along with coconut as main crop are relatively labour intensive. This proved the statement that mixed cropping systems offer a means of promoting diversity of diet and income, stability of production, reduced insect and disease incidence, efficient use of labor, intensification of production with limited resources, and also maximization of returns under low levels of technology.

In general, the cost incurred during the first year for establishing a garden was relatively higher than the remaining years of gestation period. It had the share of 44 per cent, 33.9 per cent, 38.25 per cent, 34.28 percent and 35 percent of total cost in cropping system I, II, III, IV and V respectively. The reason is obvious that, during first year it included huge initial investment and maintenance expenditure.

Share of the material cost in the first year constituted 62.9 per cent for cropping system I, 35 per cent for cropping system II, 45.53 per cent for cropping system III, 43.14 per cent for cropping system IV, and 40.2 per cent for cropping system V. Higher share of the material cost was due to investment on fixed inputs such as fencing material, seedlings, pump house, pump sets etc. Among these, the investment on pump set and pump house was highest in mixed cropping system as it requires comparatively higher capacity than other systems.

Labour cost had the share of 37.1 per cent for cropping system I, 65 per cent for cropping system II, 54.47 per cent for cropping system III, 56.86 per cent for cropping system IV, and 59.8 per cent for cropping system V. This higher share was mainly due to labour intensive pre-planting operations viz. planting, digging of pits, land leveling etc. Higher planting cost in mixed cropping along with coconut as main crop was due to the fact that majority of the growers in this group did the operations on contract basis for which growers had to pay little higher charges.

Out of the total material cost, investment on manure is more thus indicating one of the major input. Out of the total labour cost, manuring and irrigation occupied a considerable share due to their labour intensive operations. In all the cropping systems, there was a steady increase in the application of inputs viz., manures, fertilizers, etc. was observed in all the component crops. This was due to the fact that with the increase in the age of the plant the requirement of input also varied from year to year during the establishment period of the cropping systems.

4. **MAINTENANCE COST OF FIVE MIXED CROPPING SYSTEMS**.

The cost incurred during bearing period on inputs, labour and fixed inputs forms the maintenance cost. The total maintenance cost was Rs.59,293, Rs.1,03,723, Rs.1,14,427, Rs.1,16,957.18 and Rs.1,46,404 for cropping system I, II III, IV and V respectively. On an average the material cost worked out to Rs.19,755.04, Rs.42,546.36, Rs.50,502.18, Rs.50,152.18and Rs.72,358.79 in cropping system I, II, III,IV and V in that order.

Of the total material cost, cost incurred on manure accounted for 34 per cent, 41.01 per cent, 43.13 per cent 42.88 percent, and 49.42 percent, of the material cost in cropping system I, II, III,IV and V respectively. This result is in conformity with Khan (1972) who reported the share of manure in the material cost was to the extent of 43 per cent. Next important item in the material cost is cost of green leaves which accounted for 42, 43.2,24, 20, and 14 per cent in cropping systems I, II, III, IV and V respectively. Thus, manure and green leaves were the major inputs used in all the five categories of gardens. It may be noted that while coconut require higher amount of green leaves while the arecanut require larger quantity of manure.

The investment on the fertilizer had the share of 14% per cent in cropping system I, 12% per cent in cropping system II, 6%% per cent in cropping system III, 6% per cent in cropping system IV, 5% per cent in cropping system V. Use of the fertilizer went on decreasing with

increasing the number of mixed crops along with coconut as main crop**.** It supports our statement that mixed cropping systems, which are often without synthetic inputs and based on integrated management of local natural resources and, in many cases, on rational management of biodiversity, theoretically offer numerous ecological advantages. Faced with the critical situation of intensive monocultures, new conceptual ways of constructing sustainable agro ecosystems is desired. Numerous studies report that plant communities with some degree of genetic heterogeneity have advantages over pure stands, debates and controversies remain on the exact role of biodiversity in ecosystem functioning and productivity.

The cost of plant protection chemicals accounted for 0.99 to 2 per cent in cropping system I, II, III,IV and V respectively . It is observed that, plant protection chemicals were applied only for areca palms as the crop is susceptible to "Koleroga" disease. In all the systems none of the farmers used PPC to coconut. It supports our statement On-farm biodiversity, if correctly assembled in time and space, can lead to agro ecosystems capable of maintaining their own soil fertility, regulating natural protection against pests, and sustaining productivity.

The other expenses included land revenue, depreciation on pump sets, maintenance of pump sets, etc. which amounted to Rs.11, 927.96 (20% of total cost), to Rs.30,156 (26 % of total cost) in cropping system I, to V respectively.

In all the systems the cost of labour accounted for almost 50 per cent of the total cost which indicated the labour intensive operations of coconut and mixed cropping systems along with coconut as main crop. Among the various labour operations, irrigation was one of the labour intensive operations in all the cropping systems as the plantation necessarily requires irrigation.

Basin digging was one of the labour intensive operations which is done once in 3 years for coconut and once in two years for arecanut plants. The mandays required were 251, 282,307,330 and 399 in cropping systems I, II, III, IV and V in that order. It proved our statement that Mixed cropping solves the seasonal unemployment problem in agriculture as the labour requirements increases along with increase in the degree of cropping intensification.

The higher amount of labour requirement for basin digging was observed in cropping system II to V compared to cropping system I. Due to the recent remunerative prices for arecanut, most of the farmers are carrying the basin digging operation regularly once in a year. As compared to medium and large farms in which the major aim is only market-oriented production and profit maximization, in case of the small holder, the farm and the household is closely linked with

regard to operations and objectives. The major aim of the small farmers is to stabilize their farm income through capital accumulation in the form of animals or plantations or by technical, social, and economic achievements. Hence small farms are also known as multi-objective farms.

The cost incurred on manuring was highest in cropping system V (Rs.29,408) followed by cropping system IV (Rs.25,888) , cropping system III (Rs.23,008), cropping system II (Rs.23,008), and cropping system I (Rs.19,755.04),. This variation was primarily due to variation in the planting density. As it is discussed earlier cropping system V had highest planting density (350 areca palms, 122 coconut,650 Banana,450 Pepper and 10,000 Pineapple) followed by cropping system IV(400 areca palms, 120 coconut,650 Banana,520 Pepper.) , cropping system III (350 areca palms, 122 coconut,800 Banana.) cropping system II (525areca palms, 140 coconuts.)

The variation in labour cost in different operations among the cropping systems was mainly due to variation in plant density. Manual operations are necessary in the cropping systems as possibility of mechanisation is quite meager in the plantations. Thus mixed cropping of coconut with other perennials helps to create additional employment to small and marginal farmers and agricultural labourers in plantation areas.

5. YIELD AND RETURN IN DIFFERENT CROPPING SYSTEMS.

The yield and returns of different cropping systems presented in the Table 7.15 to 7.19 are discussed as below. The yield of plantation crops generally undergoes different phases i.e., increasing yield, stabilised yield and declining yield. In the present study the yield of coconut and arecanut showed similar trend in different cropping systems. However, yield per unit area of land depend on the planting density and level of management.

In all the systems, the yield of coconut was highest at the palm age of 21-35 years. The per hectare yield of coconut was highest in the cropping system I compared to other systems. This was mainly attributed to high planting density of coconut. However, the per palm yield was also highest in the monocarp of coconut (75 nuts/palm) followed by cropping system II (56 nuts/palm),cropping system III (59 nuts/palm) cropping system IV (58 nuts/palm), and cropping system V (53 nuts/palm).. As both coconut and arecanut are shallow rooted crops which may compete for the soil nutrients at same level of soil depth. It was also learnt during the survey

that, variation in the yield was due to difference in the quality of manures (FYM, compost and vermicompost) used and the improvements made on the farm to conserve moisture.

Copra making was the common practice among all the farmers who were practicing different cropping systems in the study area. Yield of copra was highest at 21-35 years age of palm in all the three cropping systems. The reason is quite obvious that the yield per palm was highest at the age of 21r35 years compared to 8-20 years and 36-50 years age of the palm. The quantity of copra produced among the cropping systems at different age of the palm varied between 60 to 389 kgs. The highest per hectare yield of copra in the cropping system I followed by II III, IV and V was mainly due to variation in the coconut population per unit area.

The yield of arecanut in the cropping system II was relatively less (7.18 to 8.20 qtl/ha). The yield variation among these two systems was mainly attributed to variation in the planting density. Per palm yield was also higher in the cropping system III, IV and V compared to cropping system II though both areca nut and coconut compete for the available moisture and soil nutrients at the same depth of soil. The farmers who are practicing cropping system III with high planting density of areca were able to realise higher yield due to their better input management and less root competition as proper alignment of plant was taken. This supports the statement the light interception in a cropping system influences the growth, productivity and biomass production of the component crops. Although the full yield potential-cannot be realized in many crops under the system as much as that obtained under mono cropping system, the reduced yield itself is indicative of their adaptability to low light profiles.

The returns realised in mono crop of coconut (cropping system) was Rs.94,846.19 in the age of 8-20 years, Rs.97,383.00 in 21 35 years and 92,335.00 in 36-50 years age of the palm. Due to the variation in the yield the variation in the returns realised was observed at different age of the palms. Similar trend was noticed in all the cropping systems. The returns realised from a mixed cropping was additional income to the farmers of cropping system II, III,IV,and V. The returns from mixed cropping in cropping system II, III,IV,and V were almost 3 times higher than the cropping system I. The reason is quite obvious that, the per hectare yield levels of mixed cropping was higher in the cropping system II , III,IV,and V due to high plant density.

Further, for the farmers cropping system III, IV and V banana, Pepper and Pineapple are providing additional income. Thus the total returns generated in the cropping system II , III,IV,and V was 3 times higher than the cropping system I respectively. This supports our

statement The main advantage of intercropping is the more efficient utilization of the available resources and the increased productivity compared with each sole crop of the mixture Yield advantage occurs because growth resources such as light, water, and nutrients are more completely absorbed and converted to crop biomass by the intercrop over time and space as a result of differences in competitive ability for growth resources between the component crops, which exploit the variation of the mixed crops in characteristics such as rates of canopy development, final canopy size (width and height), photosynthetic adaptation of canopies to irradiance conditions, and rooting depth**.**

6. FINANCIAL FEASIBILITIES OF INVESTMENT IN DIFFERENT CROPPING SYSTEMS. COMPARATIVE PROFITABILITY OF DIFFERENT CROPPING SYSTEM**.**

It is observed that, the cost of establishment and maintenance cost was highest in the cropping system V followed by cropping system IV,III, II and I. The higher cost of establishment was due to the involvement of investment costs for component crops like arecanut in cropping system II and arecanut, banana in cropping system III and arecanut, banana and Pepper in cropping system IV and arecanut, banana, Pepper and Pineapple in cropping system V. For the same reason the cost of maintenance followed the similar trend. However, it can be seen from the Tables 7.11 to 7.14 that in mixed cropping systems some of the operations are common for component crops. This points out that, the growing of companion crops besides generating additional returns helps to bring down the cost of cultivation by sharing some of the common cultural operations. It supports the statement that the main advantage of mixed cropping is the more efficient utilization of the available resources and the increased productivity compared with each sole crop of the mixture**.**

The gross and net returns generated from the cropping system V ranked top order followed by cropping system IV, III, II and I. The low returns generated in cropping system II may be due to lack of management of input levels. Thus it showed compatibility of arecanut in coconut garden and the mixed cropping system along with coconut with banana, with pepper and with pineapple (cropping system III,IV,and V) showed feasibility.

The total number of man days created was highest in cropping system V (399 man days) followed by cropping system IV(330 man days) cropping system III (307 man days) cropping system II(282 man days) cropping system I (251 man days). Thus it is amply clear that growing

of mixed crops like arecanut, banana, Pepper and Pineapple in coconut gardens helps to create employment to small and marginal farmers besides generating additional returns. In cropping system II, III IV and V cultural operations of component crops spreads throughout the year thereby helps to bring the additional employment. The returns from coconut, arecanut, banana, Pepper and Pineapple in cropping system II, III IV and V will be almost round the year. It supports our statement that Different gestation period of mixed crops contribute to the development of weekly village market throughout the year. One important reason for which intercropping is popular in the developing world is that it is more stable than mono cropping. The stability under mixed cropping can be attributed to the partial restoration of diversity that is lost under mono cropping. From this point of view, intercropping provides high insurance against crop failure, especially in areas subject to extreme weather conditions such as frost, drought, flood, and overall provides greater financial stability for farmers, making the system particularly suitable for labor-intensive small farms. Thus, if a single crop may often fail because of adverse conditions such as frost, drought, flood, or even pest attack, farmers reduce their risk for total crop failure by growing more than one crop in their field.

7. INVESTMENT EVALUATION IN THE FIVE CROPPING SYSTEMS.

To evaluate the feasibility of investment in different cropping systems, the evaluation criteria such as Net Present Value (NPV), Benefit-Cost Ratio (BCR), Internal Rate of Returns (IRR) and Payback Period (PBP) were employed.

Net Present Value (NPV)

The results revealed that the net present value over the economic life period was Rs.1, 04,340.17, Rs.1, 61,821.15 ,Rs. 3,56,689.00 Rs.4,19,832.06 and Rs. 5,03,952.90 in cropping system I, II ,III,IVand V respectively. NPV was directly proportional to the returns obtained from the system. The studies conducted by Anonymous (1988) revealed the same. As the net present value was positive in all the systems, the investment on mixed cropping systems along with coconut was found to be economically feasible.

Benefit-Cost Ratio (BCR): The discounted benefit-cost ratio indicates the net returns realised per rupee of investment during the economic life period of the gardens. The benefit-cost ratio worked out to 1.59, 1.47, 2.80,3.20 and 3.92 for cropping system I, II,III, IV and V respectively**.** This criterion also placed cropping system V at the top followed by cropping system IV, III, II

and I However, benefit cost ratio is greater than unity for all the categories of gardens, the investment in these gardens is economically feasible and viable. Internal rate of return (IRR): The internal rate of return on different systems worked out to be 32.50, 34.00, 36.00, 37.50 and 38.00 per cent in cropping system I, II III, IV and V respectively. The internal rate of return was higher than the discount rate (14%) considered in the evaluation criteria. In this criteria cropping system V at the top in its profitability followed by cropping systems IV,III,II and I. Thus, all the five criteria of project evaluation viz., the net present worth, benefit cost ratio and internal rate of return indicated that investment in all the four mixed cropping systems along with coconut was economically feasible and financially sound.

Payback period (PBP): The payback period refers to the time to repay the initial investment. The payback period was 8.3, 8.5, 8.7, 9.5 and 9.6 years in cropping systems I, II, III, IV and V in that order. This indicated that cropping system V and other mixed cropping system could partially cover the costs from the returns generated by banana, Pepper, and Pineapple during the economic life of the plantation. However, the study indicated that there was not much difference in the time needed to recover the initial investment. The higher time taken in coconut with arecanut was due to low returns. Investment on the crops such as coconut, oil palm and rubber was economically feasible based on IRR and B: C ratio. Hence in the present study higher IRR and B: C ratio indicated that the investment in all the five cropping systems was found to be feasible.

8. PROBLEMS FACED BY THE FARMERS IN DIFFERENT CROPPING SYSTEMS.

Regarding the use of organic manure, most of the farmers who are practicing system I and II expressed lack of capital as the major constraint. Non-availability of organic manure was the major constraint in the farms of cropping system V and to cope up with the situation farmers were used farm yard manure and hence they felt not necessary of applying any organic manure.

Regarding the usage of inorganic fertilizer most of the farmers who are practicing different cropping systems felt that it was not necessary. They had the opinion that application of inorganic fertilizers will affect the soil health. Few of the farmers expressed that they were not aware of recommended dose of inorganic fertilizers due to their practice of traditional method of cultivation. Scarcity of water and high labour cost were the major hindrances in carrying irrigation to the crops. To control Rhinosorous beetle in coconut, most of the farmers have

followed mechanical control in all the system as they are not aware of BHC recommendation. In this regard technical guidance should be strengthened especially from the developmental departments like 'Horticulture'. Majority of the farmers (60-80% in all the systems) expressed lack, of availability of quality seedlings. Hence there is need to educate the farmers regarding the availability of quality seedling in different Government organisations such as coconut board, CPCRI etc.

Lack of training and seminar, lack of extension contacts were the major constraints in adoption of new knowledge in the coconut and coconut based cropping systems. In this extension activities should be strengthened in the study area by ICAR institutes or state Agricultural Universities with regard to coconut and coconut based cropping systems.

The farmers of cropping system II to V had the opinion that high labour cost was the major hindrance in the Banana, Pepper and Pineapple cultivation. On the marketing side absence of grading, storage and lack of transportation facility were the major constraints with respect to banana Pepper and Pineapple. In this line to get the benefits of remunerative prices, farmers should take the initiation and for grading the product. Construction of storage facility, etc. is need of the day in the study area. Farmers have not adopted dehusking machine in all the cropping systems which may be due to requirement of huge amount of capital.

9. IMPORTANT POLICY SUGGESTIONS

1. As indicated by financial measures, the investment made on mixed cropping systems along with coconut as main crop was found to be financially feasible. The farmers who wish to establish these gardens may do so even with borrowed amount at the prevailing rate of interest charged by financial institutions on the loans advanced.

2. In order to augment the supply of nutrients through organic manure, it was found necessary to improve the quality of organic manure by adopting scientific procedure to prepare farm yard manure/compost. In addition growing of green manure crops in the gardens was found to be necessary to augment the supply of organic manure.

3. Since fruits like Banana and Pineapple are perishable in nature to protect the farmers against fluctuation in prices cold storage facility is needed in the study area.

4. It is evident from the study that, the mixed cropping system II to V generated highest returns and number of man days. Hence the cropping system V should be popularised by the developmental departments through extension activities.

5. The non availability of quality seedlings of coconut and arecanut are the major production constraints. Hence there is need to supply the quality seedlings by Government organisations or other agencies.

6. Yield per coconut palm is comparatively low in the study area than the other coconut growing parts of the State. This was probably due to unawareness of recommended dose of fertilizers. In this line, the technical guidance should be strengthened from the developmental departments like Horticulture.

Conclusion: There seems to be a prejudice among some researchers that mixed cropping is only for peasant farming and has no place in modern agriculture. However, in many areas of the world, farmers developed complex farming systems in the form of mixed cropping systems that were well adapted to the local conditions and helped them to sustainably manage harsh environments and to meet their subsistence needs, without depending on mechanization, chemical fertilizers, pesticides or other technologies of modern agricultural science. In most mixed cropping systems by smallholders, productivity in terms of harvestable products per unit area is higher than under mono cropping with the same level of management and yield advantages can range from 20% to 60% due to reduction of pest incidence and more efficient use of nutrients, water, and solar radiation. These mixed cropping system offer promising models as they promote biodiversity, thrive without agrochemicals, and sustain year-round yields. Mixed cropping has been an important production practice in many parts of the world and it continues to be an important farming practice in developing countries. Despite its potential and multiple advantages, mainstream agronomic research has largely focused on mono crop systems, with little interest in ecological interactions between species in mixed cropping systems. Thus, although mixed cropping has been widespread in many parts of the world, it is still poorly understood from an agronomic perspective and research in this area is far less advanced than comparable work in monoculture. This is due in part to the wide use of pure crop cultures in the developed world, in part to the relative lack of resources in the developing world, but not least to the complexity of the problems involved. Thus, more research is needed to better understand how mixed crops function and to develop mixed cropping systems that are compatible with

current farming systems. It has been emphasized already that for mixed crop combination to be biologically advantageous, the mixture components need to be chosen with care. Unfortunately, the interactions among the plants, animals, and microorganisms are so subtle and specific to particular locations that present knowledge only provides a rough guide as to what new combinations of crops and varieties should be tried. Consequently, if the possible advantages of mixed cropping are to be exploited, local experimentation will be needed using a range of possible components and a series of seasons. However, in real life, it is usually not the biological but the economic advantage which decides which cropping systems are actually used. Mixed cropping often involves staggered plantings and selective harvesting and thus it tends to be labour intensive. If it is soundly practiced, it requires less pesticides and fertilizers, and therefore can be a low-polluting method of farming. Where there is rural unemployment, where capital is in short supply, and where production must be sustainable without expensive fossil fuels and pollution control mixed cropping is a possible solution. Mixed cropping systems had to have merit biologically, environmentally, economically, and sociologically. Better understanding of mixed cropping systems would lead to the increased adoption rates of these systems in the agricultural sector. Mixed cropping has great potential to be more beneficial to agriculture in the future and thus receive more attention because of its more efficient use of environmental and other resources than mono crop systems. Once the potential benefits of the mixed cropping are realized and considering the multiple advantages that can occur from mixed cropping, particularly in the seek of sustainable agricultural systems, and the environmental problems with current farming systems, it seems reasonable to continue research on the possibilities of growing more than one crop in a field at the same time.

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